Plant Breeding and Environment Protection

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SUMMARY

Plant breeders in Croatia work on improving genetic basis of the economically important traits of agricultural plant species. Yield of a crop is usually among the most important traits. It depends on genotype of a cultivar and on cultural practices including pest protection. Croatia has long tradition in plant breeding. Croatian plant breeders have developed over 800 cultivars, many of them are resistant or tolerant to the most important pathogens. Genetic variability for efficient uptake and use of nutrients has been also found among cultivars of same crops. The available germplasm enables farmers to choose the cultivars for organic agriculture, i.e. the cultivars which have genetic basis for more efficient nutrients use and which require less chemicals for pest control. Also, breeders can use those cultivars as valuable germplasm for developing new cultivars.

KEY WORDS

plant breeding - organic agriculture - pest resistant germplazm - nitrogen use efficiency

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INTRODUCTION

Man is more and more concerned about keeping environment (water, soil, plant, animal) clean from pollution and about producing food without using various chemicals in the field. From plant breeders and geneticists is expected to develop cultivars of crop species which can be grown with less chemicals which have negative environmental impact, i.e. less chemical fertilizers and chemicals for pest and weed control. Consequently, attention has been more and more payed to organic farming and breeding development of new cultivars for such agriculture. In this paper the authors present the Croatian crop species and foreign horticulture breeding achievements, which can contribute to reducing the environment pollution and producing healthy food.

PEST RESISTANCE

Resistance to diseases, nematodes and insects is often among the most important breeding goals. The resistance can be controlled by major genes and, in the segregating progenies the resistant and susceptible genotypes can be clearly distinguished. It is known as qualitative, specific or vertical resistance. This is resistance to one or several races of a disease. Basic disadvantage of this type of resistance is its short duration. Resistance controlled by minor genes is inherited as a quantitative trait and, it is known as general, polygenic, field or horizontal resistance. It controls a wide spectrum of races in a pest population. There is a genetic interaction between plant and disease (Flor 1956, according Fehr, 1987). The latter author suggested the hypothesis gen-for-gen, which could explain that interaction. According to the theory a plant having a dominant allele for resistance, i.e. A-, is resistant as long as the disease does not have recessive allele for virulence, i.e. a ("lock and key"). In the case of vertical resistance a plant resists establishment of the pathogen in its tissue, whereas in the case of horizontal resistance the plant resists growth and reproduction of the pathogen that becomes established. Finally, the plant may develop and reproduce well despite the activity of the pathogen, which is known as tolerance.

Regarding insect resistance there can be antibiosis which is the adverse effect of plant tissue used as food by an insect on its development and reproduction, nonpreference when plant characters make a cultivar undesirable as food to insects, and tolerance when cultivar grows and reproduces well despite the presence of insects which would damage a nontolerant plant (Fehr, 1987).

CROP SPECIES

Croatian plant breeders have developed about 800 cultivars of various crop and vegetable species (Kozumplik and Martinić, 2001). The cultivars have been grown in Croatia and abroad.

In the breeding programs, considerable attention has been payed to pest resistance. The Croatian breeders have been successful in developing pest resistant maize, wheat, winter and spring barley, spring oat, soybean, sunflower, sugar beet, potato and tobacco cultivars (Tab. 1). The resistant or tolerant cultivars and inbreds are listed in tables 2-6. This germplasm has been used in commercial production and represents a source of pest resistance for breeding purposes.

Table 1. Number of domestic cultivars resistant or tolerant to the most important pests

Cultivar/Pest	Resist./tol. cultivars
Maize	
Northern leaf blight (*Exserohilum turcicum*)	8 hybr.+ 2 inbreds
Black leaf spot (*Bipolaris zeicola*)	4 inbreds
Anthracnose-stalk (*Colletotrichum graminicola*)	5 hybr.+ 5 inbreds
Anthracnose-leaf (*Colletotrichum graminicola*)	2 inbreds
Maize eyspot (*Kabatiella zeae*)	1 inbreds
Stalk rot (*Fusarium spp.*)	10 hybr.+ 6 inbreds
Ear rot (*Fusarium graminearum*)	15 hybr.+ inbreds
Maize borer (*Ostrinia nubilalis* Hubner)	5 hybr.+ 3 inbreds
Maize rootworm (*Diabrotica virgifera*)	6 hybrids
Wheat	
Stem rust (*Puccinia graminis f. sp. tritici*)	7
Leaf rust (*Puccinia recondita f. sp. tritici*)	6
Stripe rust (*Puccinia striiformis f. sp. tritici*)	2
Powdery mildew (*Erysiphe. graminis*)	11
Fusarium (*Fusarium graminearum* Schw.)	9
Glume Blotch (*Septoria nodorum* Berk.)	6
BYDV	1
Cereal leaf beetle (*Oulema melanopus*)	1
Winter barley	
Powdery mildew (*Erysiphe graminis f. sp. hordei*)	6
Scald(*Rhyncosporium secalis*)	5
Net blotch (*Pyrenophora teres*)	4
Burley stripe (*Pyrenophora gramineum*)	4
Rust (*Puccinia spp.*)	6
Loose smut (*Ustilago nuda*)	2
Covered smut (*Ustilago nigra*)	2
Barley stripe (*Helmin. gramin.*)	2
Spot blotch (*Cochliobolus sativus*)	1
Spring barley	
Powdery mildew (*Erysiphe graminis f. sp. hordei*)	5
Scald (*Rhyncosporium secalis*)	5
Net blotch (*Pyrenophora teres*)	4
Spring oat	
Loose smut (*Ustilago avenae*)	2
Oat cover smut (*Ustilago kolleri*)	2
Stem rust (*Puccinia graminis f. sp. avenae*)	1
Leaf spot (*Leptosphaeria avenaria*)	1
Soybean	
Downy mildew (*Peronospora manshurika*)	4
Pod and stem blight (*Diaporthe phaseolorum var. sojae*)	3
Stem canker (*Diaporthe phaseolorum var. caulivora*)	3
Sclerotinia stem rot (*Sclerotinia sclerotiorum*)	1

continue (Table 1)

Sunflower	
Phomopsis (*Diaporthe belianti* Munt.)	3
Downy mildew (*Plasmopara halstedi*)	2
Septoria leaf spot (*Septoria helianthi*)	3
Alternaria (*Alternaria helianthi*)	5
Phoma black stem (*Phoma macdonaldi*)	5
Sclerotinia (*Sclerotinia sclerotiorum*)	3
Charcoal stemrot (*Macrophomina phaseoli*)	3
Botrytis (*Botrytis cinerea*)	2
Lygus-bugs (*Lygus spp.*)	2
Sunflower moth(*Homoeosoma nebulellum* Hb)	4
Sugar beat	
Cercospora leaf spot (*Cercospora beticola*)	4
Potatoes	
Late blight (*Phytophtora infestans*)	6
Leaf roll v., Potato v. X, Potato v.A, PVY (PLRV, PVX, PVA)	6
Wart (*Synchytrium endobioticum*)	4
Tobacco	
Blue mold (*Peronospora tabacina* Adam)	2
Potato v.Y (PVY)	7
Blue mold + PVY	1

Table 2. Domestic maize hybrids and inbreds resistant/ tolerant to the most important pests

Pest	Hybrid/Inbred		
	Bc Institute		Os Institute
Northern leaf blight (*Exserohilum turcicum*)	ETA 272	Bc 9	Os 140-9
	Bc 278	Bc 10	Os 84-49
	Bc 288 B	Bc 825	Os 87-61
	Bc 354	Bc 153	Os 140/4
	Bc 412	Bc 273	Os 89-29
	Bc 462	Bc 742	Os 1-44
	Bc 566		
	Dunav		
Black leaf spot (*Bipolaris zeicola*)	Bc 489		Os 84-49
	Bc 703-19		Os 89-29
Anthraknose - stalk (*Colletotrichum graminicola*)	Bc 394	Bc 10	Os 23-48
	Bc 404	Bc 19064	Os 1-48
	Bc 492		Os 438-95
	Bc 566		
	Bc 592		
Anthraknose - leaf (*Colletotrichum graminicola*)		Bc 10	Os 6-2
Maize eyespot (*Kabatiella zeae*)			Os 6-2
Stalk rot (*Fusarium spp.*)	Bc 318	Bc 703-19	Os 438-95
	Bc 354	Bc 400	Os 163-9
	Bc 358	Bc 402	
	Bc 394	Bc 407	
	Bc 418 B		
	Bc 492		
	Bc 566		
	Bc 592		
	Dunav		
	Bc 678		
Ear rot (*Fusarium graminearum*)	Bc 182	Bc 344	Os 23-48
	Bc 278	Bc 920768	Os 1-48
	Bc 288 B		Os 438-95
	Bc 304		Os 24-48
	Bc 318		Os 524
	Bc 354		

continue (Table 2)

	Bc 358		
	Bc 404		
	Bc 408 B		
	Bc 412		
	Bc 462		
	Bc 492		
	Bc 592		
	Bc 5982		
	Bc 6661		
Maize borer (*Ostrinia nubilalis* Hubner)	Bc 408 B		Os 23-48
	Bc 4982		Os 30-48
	Bc 5982		Os 24-48
	Bc 6661		
	Bc 778		
Maize rootworm (*Diabrotica virgifera*)	Bc 288 B		Os SK602
	Bc 354		
	Bc 462		
	Bc 4982		
	Dunav		
	Bc 678		

Table 3. Domestic wheat cultivars resistant/tolerant to the most important pests

Pest	Cultivar		
	Bc Institute	Os Institute	Faculty of Agriculture Zagreb
Stem rust (*Puccinia graminis f. sp. tritici*)	Marija		
	Sana		
	Patria		
	Tina		
	Liberta		
	Prima		
	Lana		
Leaf rust (*Puccinia recondita f. sp. tritici*)	Liberta	Srpanjka	Kuna
	Aura	Monika	Banica
Stripe rust (*Puccinia striiformis f. sp. tritici*)			Kuna
			Banica
Powdery mildew (*Erysiph graminis*)	Sana	Monika	Kuna
	Patria		Banica
	Tina		Magdalen
	Prima		Lipa
	Nina		
	Lana		
	Primadur		
Fusarium (*Fusarium graminearum* Schw.)	Marija		Kuna
	Liberta		Banica
	Mihelca		Magdalen
	Zdenka		
	Aura		
	Prima		
Glume blotch (*Septoria nodorum* Berk.)	Patria		
	Tina		
	Mihelca		
	Zdenka		
	Nina		
	Primadur		
BYDV			Banica
Leaf beetle (*Oulema melanopus*)		Žitarka	

Table 4. Domestic barley and oat cultivars resistant/tolerant to the most important pests

Pest	Cultivar	
	Bc Institute	Os Institute
Winter barley		
Powdery mildew (*Erysiphe graminis f. sp. hordei*)		Sladoran Pan Rodnik Danko Podravac Usk 848/9-98
Scald (*Rhyncosporium secalis*)		Danko Dorat Podravec Lord Olimp
Net blotch (*Pyrenophora teres*)		Danko Rex Sladoran Rodnik
Barley stripe (*Pyrenophora gramineum*)	Favorit Rekorder	Danko Rex Sladoran Rodnik
Rust (*Puccinia spp.*)	Favorit Rekorder	Rodnik Zvonimir Baja David
Loose smuth (*Ustilago nuda*)		Alkar Mursa
Covered smuth (*Ustilago nigra*)	Favorit Rekorder	
Spot blotch (*Cochliobolus sativus*)	Favorit	
Spring barley		
Powdery mildew (*Erysiphe graminis f. sp. hordei*)		Astor Vitez Darko Lunar Jaran
Scald (*Rhyncosporium secalis*)		Igor Darko Dominik Lunar Jaran
Net blotch (*Pyrenophora teres*)		Astor Vitez Dominik Baltazar
Spring oat		
Loose smut (*Ustilago avenae*)	Baranja Kupa	
Cover smut (*Ustilago kolleri*)	Baranja Kupa	
Stem rust (*Puccinia graminis f. sp. avenae*)	Baranja	
Spot blotch (*Leptosphaeria avenaria*)	Kupa	

Table 5. Domestic soybean and sunflower cultivars resistant/tolerant to the most important pests

Pest	Cultivar (Os Institute)
Soybean	
Downy mildew (*Peronospora manshurika*)	Ika Podravka 95 Nada Anica
Pod and stem blight (*Diap. phaseolorum var. sojae*)	Ika Podravka 95 Anica
Stem canker (*Diap. phaseolorum var. caulivora*)	Ika Nada Anica
Sclerotinia stem rot (*Sclerotinia sclerotiorum*)	Anica
Sunflower	
Phomopsis (*Diaporte helianti* Munt.)	Fakir Orion Favorit
Downy mildew (*Plasmoparab halstedi*)	Apolon Olio
Septoria leaf spot (*Septoria helianthi*)	Fakir Favorit Apolon
Alternaria (*Alternaria helianthi*)	Fakir Orion Olio Favorit Apolon
Phoma black stem (*Phoma macdonaldi*)	Fakir Orion Olio Favorit Apolon
Sclerotinia (*Sclerotinia sclerotiorum*)	Fakir Orion Favorit
Charcoal stemrot (*Macrophomina phaseoli*)	Fakir Orion Favorit
Botrytis (*Botrytis cinerea*)	Olio Apolon
Lygus-bugs (*Lygus spp.*)	Olio Apolon
Sunflower moth (*Homoeosoma nebulellum* Hb)	Fakir Olio Favorit Apolon

FRUIT AND GRAPEVINE

Croatian fruit growing and viticulture, with few exceptions, is based upon cultivars introduced from abroad. For major fruit species such as grapevine, apple, peer, plum, strawberry, etc. cultivars used are fairly old. Even though the selection of the cultivar is determined by many factors, suitability for organic farming is getting more and more important.

Apple: There are already cultivars sufficiently tolerant to the most important leaf and fruit diseases, available for apple production in the EU countries. The *Vf* gene of the resistance to the apple scab (*Venturia*

Table 6. Domestic sugar beat, potato and tobacco cultivars resistant/tolerant to the most important pests

Pest	Cultivar		
	Stara Sušica	Institute of sugar beat Osijek	Tobacco Institute Zagreb Faculty of Agriculture Zagreb
Sugar beat			
Cercospora leaf spot (*Cercospora beticola*)		Os Sana Os Ana Iva Kaja	
Potato			
Late blight (*Phytophtora infestans*)	Stanka Dalmatinka Nada Istra Lika Goran		
Leaf roll v., Potato v. X, Potato v. A (PLRV, PVX, PVA)	Stanka Dalmatinka Nada Istra Lika Goran		
Potato v. Y + Wart (PVY, Synchytrium endobioticum)	Istra Stanka Dalmatinka Nada		
Tobacco			
Blue mold (*Peronospora tabacina* Adam)			H31 DH10
Potato v. Y (PVY)			H31 DH10 DH16 DH17 DH18 DH19 VaDK BHT1

inequalis) was originally introduced by hybridization from wild species *Malus floribunda*, and today there are available cultivars carrying that gene such as Prima, Priscilla, Sir Prize, Jonafree, Redfree, Dayton. Later on, it was discovered existence of many races of the *Venturia inequalis,* requiring different resistance genes that were symbolized according to the sources they were discovered from (*Vm, Vr, Vbj, Vb, Va*). Recently released American cultivars like Liberty and Williams posess complex resistance based on a large number of resistance genes to different races of *V. inaequalis*, as well as other diseases like fire blight (*Erwinia amylovora*), and mildew (*Podosphaera leucotricha*) (Crosby et al., 1992). New German cultivars Remo, Reanda and Rewena demonstrate multiple resistance to different diseases and some pests, and resistance to low temperatures and frost (Fisher et al., 1997). Intensive apple breeding programs to the resistance against the most important diseases are carrying out in the USA, England, Germany, France, the Netherlands, Czech Republic, Poland, Romania and Russia.

Pear: Fire blight (*Erwinia amylovora*) caused enormous damages in pear plantations in Croatia during last years. Curative treatment measures are ineffective beacuse it is caused by the bacteriosis. Thus, the appropriate solutions are healthy planting material and resistant cultivars. Few older and some more recent cultivars of pear (*Pyrus communis*) like Alexander Lucas, Tyson, Seckel, Maxine, Harrow Delight, Harrow Sweet, Moonglow and Magness demonstrate moderate tolerance to fire blight (Bell et al., 1996). Interspecies hybridization with genotypes of *Pyrus pyrifolia* resulted in resistant cultivars Le Conte, Kieffer and Garber, and newer Gourment and Honeysweet, but their quality is lower. However, there are large number of resistant Chinese cultivars carrying the resistance genes originating from *Pyrus ussuriensis* that might serve as a source of resistance in the future breeding programs.

Plums: The main limiting factor in the plum production in Croatia, as well as in the great part of Europe is a virus caused disease - PPV (sharka). Similarly to fire blight in pears, the only solution are resistant cultivars and laboratory tested healthy planting material (virus-tested). Polygene control of this resistance was reported in several studies which is in accordance with fact that available cultivars demonstrate a different level of tolerance. Among these relatively tolerant cultivars is *cv.* Stanley which is very popular in Croatia. Recently, qualitative genes that may demonstrate total resistance to some races of virus are reported. It seems that hybridization of resistant cultivars like Scoldus No. 1 and Zh'lta Butilcovidna could result in obtaining genotypes of satisfying resistance (Ranković et al., 1994). Hartmann (1991) reported on resistant clones of the cultivar Buehler Fruezwetsche suggesting control by single gene of great effect for PPV resistance. However, the majority of cultivars with horizontal type of resistance, especially in dry years, show insufficient level of tolerance. *Cv.* Jojo (Stanley x Ortenauer) was registered in Germany in 1999 as a new cultivar with declared total resistance to PPV. Cv. Jojo performs very well regarding important economic traits (self-fertility, early-maturing, high crop yield and quality). In the serial of trials with artificial and natural infection over many years it demonstrated the total resistance to PPV (Hartmann and Petruschke, 2000).

Grapevines: Grapevine is being ahead of all other cultivated crops in term of consumption of the plant protection chemicals. Development of grapevine cultivars resistant to the most important diseases of leaf and bunch, by retaining quality in the same time, is very prospective task. Almost all of more than 140 cultivars from Croatian national variety list manifest more or less susceptibility to the economically most important diseases (powdery and downy mildew, botrytis). This is the matter of only European or "noble" vines (*Vitis vinifera* L.). Breeders have on disposal the great number of resistance genes from wild species from America and Asia, but due to traditional explicitness of International Office of Vine and Wine (O.I.V.) the leading wine producing countries, where Croatia belongs too, have incorporated to their wine laws the ban of "non-vinifera" species to be used for wine production. In spite of this, during the several years in Europe exist several breeding programs that resulted in cultivars demonstrating the great tolerance to the most important diseases and requiring the minimal level of chemical protection, retaining the high quality of grapes. Resistant cultivars, due to ecological reasons, are expected to take greater production share in close future, and the legislative might, respectively, change especially for the fact that the resistant cultivars of new generation are not inferior to the quality of the cultivars with 100% *Vitis vinifera* origin. The cultivars Regent, Phoenix, Sirius and Merzling, were registered in Germany in the "vinifera" category despite the small share of the genes originated from the wild genomes. These are considered as perspective and are gradually spreading in Germany and Austria (Ambrosi et al., 1998). New cultivars Panonia and Morava created at the Faculty of Agriculture in Novi Sad, besides high resistance to the most important diseases of leaf and bunch prooved also high level of frost tolerance, making them appropriate for production in conditions of continental climate with strong winters (Cindrić, personal communication).

FERTILIZATION

In year 2000 about 10.000.000 t of organic fertilizers were produced in Croatia (Posavi, 2000). Within last ten years production of organic fertilizers decreased because of a decreasing number of domestic animals.

Application of chemical fertilizers indicates the intensity of agricultural production. Highest average rate of fertilization in Croatia in 2000 was 550 kg of mineral fertilizers per ha of arable land at Požeško-slavonska County. At the same time, average consumption of chemical fertilizers at Ličko-senjska and Primorsko-goranska County was below 20 kg/ha of arable land (Tab. 7).

Fate of nitrogen added with chemical fertilizers is dependant on many agro-ecological factors, i.e. precipitation, air humidity, soil and air temperatures, etc. Leaching of nitrogen is conditioned by fertilization rate, soil properties, intensity and amount of precipitation, crop type and stage of development, etc. In October 2001 at the Second International Nitrogen Conference in Washington

Table 7. Application of chemical fertilizers in Croatia in 2000*

County	Total chemical fertilizers (t)	Active ingredient (t)	kg of fertilizers / ha agricultural land	kg fertilizers / ha of arable land
Zagreb	42.236	17.664	208	234
Krapina and Zagorje	12.963	5.019	184	210
Sisak and Moslavina	21.559	9.165	95	116
Karlovac	7.170	3.161	35	69
Varaždin	20.726	8.542	293	315
Koprivnica and Križevci	30.936	12.674	297	304
Bjelovar and Bilogora	30.867	12.357	209	215
Primorje and Gorski Kotar	848	393	6	18
Lička and Senj	2.104	915	8	19
Virovitica and Podravina	45.807	19.622	380	401
Požega and Slavonija	42.413	18.064	472	550
Brod and Posavina	33.898	14.404	290	326
Zadar	7.159	3.108	32	167
Osijek and Baranja	83.129	36.603	322	341
Šibenik and Knin	12.088	4.934	67	290
Vukovar and Sriem	71.806	31.559	476	490
Split and Dalmatia	10.022	4.309	36	170
Istra	9.034	3.968	54	102
Dubrovnik and Neretva	2.734	1.250	36	122
Međimurje	17.242	7.518	324	337
Total	505.000	215.000	160	253

Table 8. Agronomic traits of flue-cured tobacco after application of various quantaties of chemical fertilizers, Kutjevo, Virovitica, 2002.

Cultivar	Kutjevo			Virovitica		
	Yield (kg/ha)	Price (kn/kg)	Value (kn/ha)	Yield (kg/ha)	Price (kn/kg)	Value (kn/ha)
			N-P-K = 40-25-150 kg/ha			
KH2	2921 ABC*	8,47 A	24570 A	3251 A	11,27 A	36700 A
KH4	2680 A-E	9,08 A	24290 A	3273 A	10,33 A	33730 A
KH17	2450 C-F	8,63 A	21030 A-D	3108 A	10,94 A	33980 A
KH19	2542 B-F	7,50 A	18380 B-E	3211 A	10,40 A	33220 A
KH23	3068 A	7,70 A	23580 ABC	3186 A	10,52 A	33370 A
KH24	2487 B-F	7,18 A	17790 CDE	3110 A	6,91 B	21750 B
KH25	2264 EFG	7,77 A	17600 DE	2983 A	9,77 A	29450 AB
DH17	2742 A-D	8,21 A	22120 A-D	3383 A	10,48 A	35660 A
			N-P-K = 60-35-210 kg/ha			
KH2	3042 A	7,89 A	23750 AB	3267 A	10,24 A	33760 A
KH4	2530 B-F	7,75 A	19240 A-A	3280 A	10,47 A	34180 A
KH17	1861 G	7,30 A	13420 E	2980 A	9,52 A	28210 AB
KH19	2380 DEF	8,31 A	19600 A-D	2936 A	8,97 AB	26320 AB
KH23	2844 A-D	7,91 A	22030 A-D	3269 A	9,84 A	32200 A
KH24	2449 C-F	7,58 A	18460 B-E	2984 A	8,77 AB	26560 AB
KH25	2174 FG	8,55 A	18220 B-E	3195 A	9,08 AB	29580 AB
DH17	2931 AB	7,69 A	22680 A-D	3441 A	10,07 A	34960 A
Var. x Fert.	NS	NS	NS	NS	NS	NS

* Values followed by the same letter are not significantly different at p=0.05

it was concluded that:
- efficiency of nitrogen use need to be improved within the existing technologies,
- increasing the nitrogen use efficiency should increase profitability and decrease the environment pollution (Galloway and Cowling, 2001).

Leaching phosphorus from agricultural soils seems to be of little importance in Croatia at the present time.

Potassium leaching depends on intensity of its application, soil properties and climate conditions. Leaching occurs more in lighter than in heavier soils. Since potassium fertilizers are not used intensively in Croatia it could be assumed that its leaching in general is not considerable.

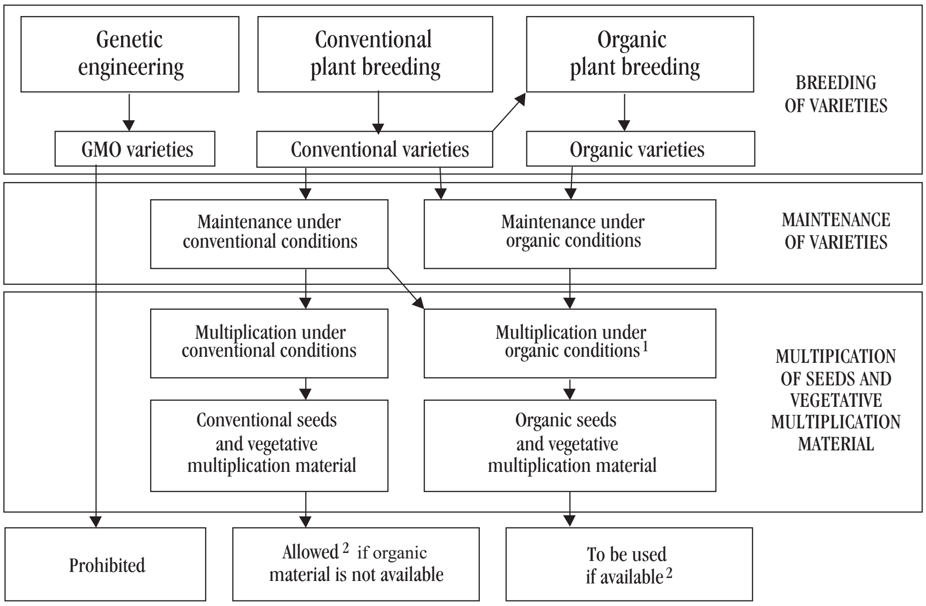
Developing cultivars for efficient N uptake from the soil and its use in the plant has been a plant breeding goal. Such cultivars grown on the soil with low N supply should (1) take N from the soil better and (2) give higher yield at a lower fertilization rate, in comparison to the less efficient cultivars. In Croatia much attention to the efficient N use has been paid in the tobacco breeding work. For a flue-cured tobacco yield of 2500 kg/ha the crop needs > 120 kg/ha of N, > 200 kg/ha of K_2O and > 50 kg/ha of P_2O_5. For good tobacco quality, N from the soil must be used up until the beginning of flowering, whereas taking P_2O_5 and K_2O from the soil continues after that time. For that purpose tobacco breeding lines and hybrids were tested at two levels of nutrient supply; N-P-K = 40-25-150 and 60-35-210 (Tab. 8). The genotypes which gave highest yield at the lower fertilization rate and still were good yielders at the higher fertilization rate were the ones selected for commercial production. Genetic variability for N-efficiency use was found in maize (Kozumplik and Pejić, manuscript) and some other species too. Extensive agriculture is usually a good test for more efficient N use cultivars.

SUCKER CONTROL AGENTS AND HERBICIDES

Tobacco is produced to be smoked and, its components nicotine and tar can affect health. Thus, by breeding and technology the nicotine and tar content has been modified in plant and in cigarette. One of the tobacco cultural practices is topping

inflorescence and sucker growth control by sucker control agents. Some of these chemicals when present in the tobacco leaf above the allowed content can affect health too (Kozumplik i sur., 2000). Tobacco breeders select genotypes with less intensive sucker growth and those which have less need for the chemicals application. In this way sucker growth is controlled genetically rather than chemically.

Breeding for resistance to herbicides has been little done by the Croatian plant breeders.



[1] Parent plants of annual crops have to be grown at least for one generation under organic conditions, while biannual plants and perennials have to be grown for at least two generations under organic conditions.

[2] These are the demands of the EU Regulation 2092/91 until the end of 2003. By 2004 organic producers will have to use only organic seeds and vegetative multiplication material.

Figure 1. Future plant breeding in the EU (Fibl Dossier, 2001)

PLANT BREEDING FOR ORGANIC AGRICULTURE

After the World War II plant breeding was aimed at obtaining cultivars for intensive agriculture based on use of large quantities of chemical fertilizers and chemicals for pest control to achieve high yields. Such varieties had to be suitable for storage too. Organic agriculture has become economically interesting to farmers, because of consumers' requirements for healthy nutrition. Farmers who practice organic agriculture use cultivars developed mostly for the intensive agriculture. It is questionable whether such cultivars are suitable for organic agricultural production. Also it is questionable whether seed produced in the classical manner is suitable for the organic production. In that respect the food consumers' expectations from the "ecological" cultivars, are that the variety product is healthy, aromatic and with flavor, or some unique type of the product. In breeding development of new cultivars classical breeding methods are used regardless of whether the cultivars are ment for classical or organic agriculture (FiblDossier, 2001). Characteristics of the cultivars for organic agriculture are:

1. adaptability to the local climate and dynamics of nutrition,
2. best possible efficiency of nutrients' use,
3. resistance or tolerance to pests,
4. good storaging ability,
5. good nutritious quality and appearance.

Thus, for organic agriculture basic breeding goal is developing cultivars efficient in taking nutrients from the soil, its "transportation" within the plant and its use in the plant. Such cultivars should be resistant or tolerant to most important pests and should not require chemical pest protection. The necessary genetic variability is available within the Croatian germplasm of most agricultural plant species and, it is possible to select cultivars among the existing ones for the organic agriculture. Organic or ecological agriculture has specific requirements regarding the seed production as well, i.e. seed should be produced under the organic agriculture conditions. In order to be completely in accordance with the organic agriculture requirements, both, cultivar and seed should be obtained under the organic agriculture conditions as shown in figure 1.

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